

PMT Status 7/29/04

Latest data on why tubes failed (and
the qual units did not)

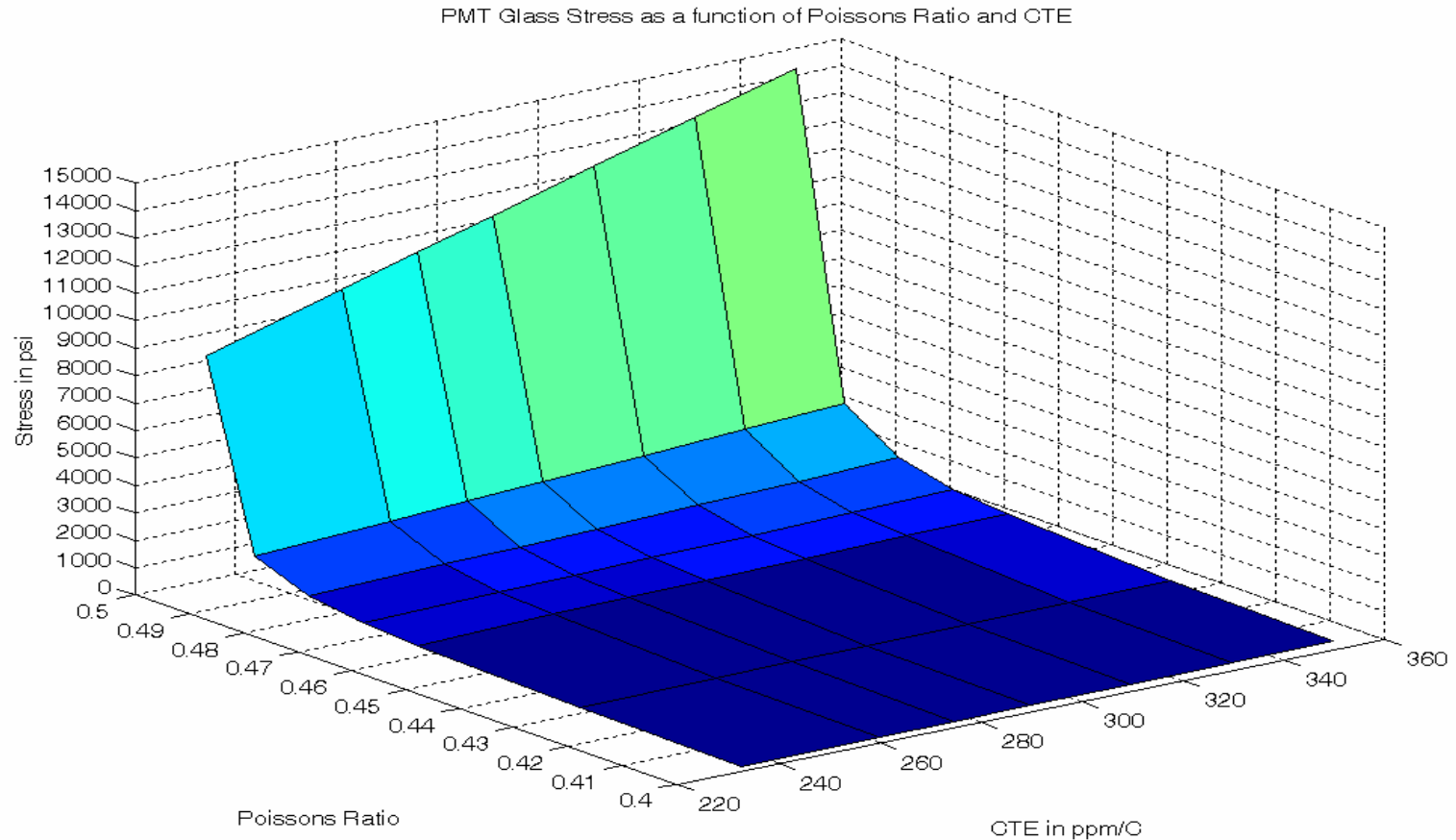
Amato, Thompson, Schmidt, He, Viens, Simmons,
Dahya, et. al.

PMT Stress as a function of CTE and Poisson's Ratio

- Raw NASTRAN analysis data
 - $\Delta T = -60^{\circ}\text{C}$ (+20 to -40°C)
 - Exterior element 4959 beneath mounting flange
 - These values are based on a FEM with RTV modeled beyond both edges of the glass tube

| RTV-566 Poisson's Ratio and CTE Sensitivity Study for PMT (Tube/RTV-566/Al Housing) Assembly | | | | | | |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| RTV-566 Poisson's Ratio | CTE 233 ppm/deg C | CTE 260 ppm/deg C | CTE 290 ppm/deg C | CTE 310 ppm/deg C | CTE 330 ppm/deg C | CTE 350 ppm/deg C |
| | Tube Stress (psi) | Tube Stress (psi) | Tube Stress (psi) | Tube Stress (psi) | Tube Stress (psi) | Tube Stress (psi) |
| 0.4 | 161 | 191 | 225 | 248 | 270 | 293 |
| 0.43 | 238 | 282 | 330 | 362 | 394 | 426 |
| 0.46 | 427 | 550 | 642 | 703 | 764 | 825 |
| 0.47 | 571 | 670 | 780 | 853 | 926 | 1000 |
| 0.48 | 847 | 993 | 1154 | 1262 | 1369 | 1477 |
| 0.49 | 1601 | 1873 | 2175 | 2377 | 2578 | 2780 |
| 0.499 | 8303 | 9699 | 11250 | 12284 | 13317 | 14351 |

PMT Stress as a function of CTE and Poisson's Ratio



| Lot/Control # | Temp. | Modulus | CTE | Poisson's ratio | Relative Stress |
|-----------------------------|-------|----------------------------|----------------------------|--------------------------------|-----------------|
| | °C | Mean (min, max, stddvt) | Mean (min, max, stddvt) | Mean (min, max, stddvt) | |
| | | MPa | ppm/°C | | psi |
| 873/CN03504 | +25°C | | 283 (tested 5/24/04) | | |
| | 0°C | | | | |
| | -30°C | | | | |
| 873/CN03504 | +25°C | 5.2 | | 0.495 (0.486, 0.505, 0.005) | 11250 |
| (casted 7/9/04) | 0°C | 5.9 | | Same as RT | |
| | -30°C | 6 | | Same as RT | |
| 873/CN03504 | +25°C | | | 0.457 (0.445, 0.469, 0.010) | 550 |
| (casted 7/19/04) | 0°C | | | | |
| | -30°C | | | | |
| 931/CN04104 | +25°C | | 245 (tested 6/9/04) | | |
| | 0°C | | | | |
| | -30°C | | | | |
| 931/CN04104 | +25°C | 5.4 | | 0.484 (0.468, 0.502, 0.015) | 1236 |
| (casted 7/9/04) | 0°C | 5.6 | | Same as RT | |
| | -30°C | 5.5 | | Same as RT | |
| 931/CN04104 | +25°C | | | 0.483 (0.472, 0.495, 0.010) | 1155 |
| (casted 7/19/04) | 0°C | | | | |
| | -30°C | | | | |
| 4031512/ CN04104 | +25°C | | 312 (tested 3/25/04) | | |
| | 0°C | | | | |
| | -30°C | | | | |
| 4031512/ CN01704 | +25°C | 4.7 | | 0.473 (0.466, 0.486, 0.009) | 984 |
| (casted 7/9/04) | 0°C | 4.9 | | Same as RT | |
| | -30°C | 4.7 | | Same as RT | |
| 4031512/ CN01704 | +25°C | | | 0.445 (0.439, 0.449, 0.004) | 537 |
| (cast 7/19/04) | 0°C | | | | |
| | -30°C | | | | |
| 0404283/ CN02804 | +25°C | | 287 | | |
| | 0°C | | | | |
| | -30°C | | | | |
| 03021411/ (834, 447, 30) | +25°C | | 377 | | |

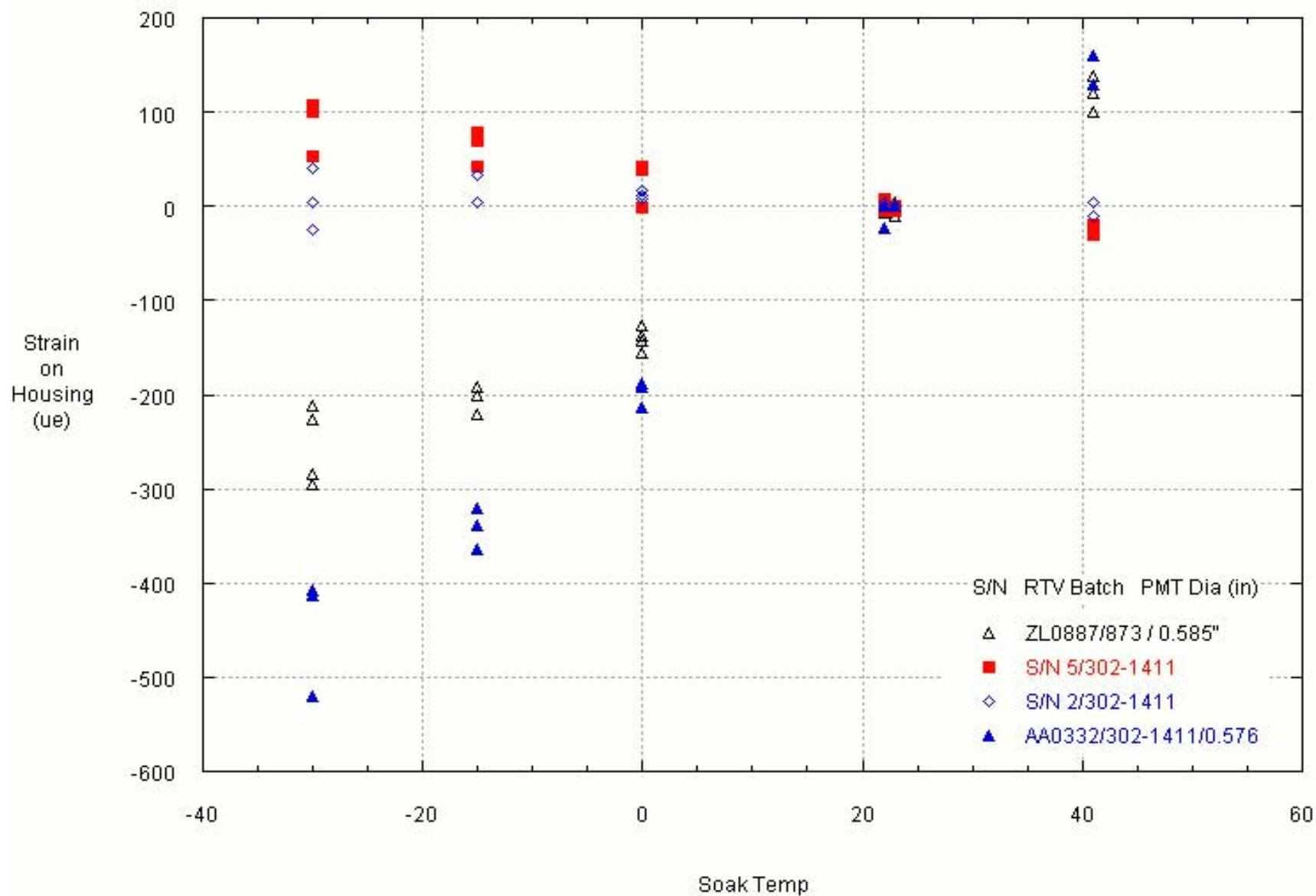
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Stress results

- Material properties are all over the place
- Improved Tests show changes between RTV batches and between different cures within same batch – in one case within batch differences (Poisson's Ratio has biggest effect, we have developed a better test for that now) apparently cause more than a order of magnitude difference
- We have good confidence in the latest material property results (test set up and repeatability)

Glast PMT Housing Hoop Strain



What do we think the strain data could mean - hypothesis

Material property change between batches and between cures (Poisson's ratio, CTE, Bubbles - samples)

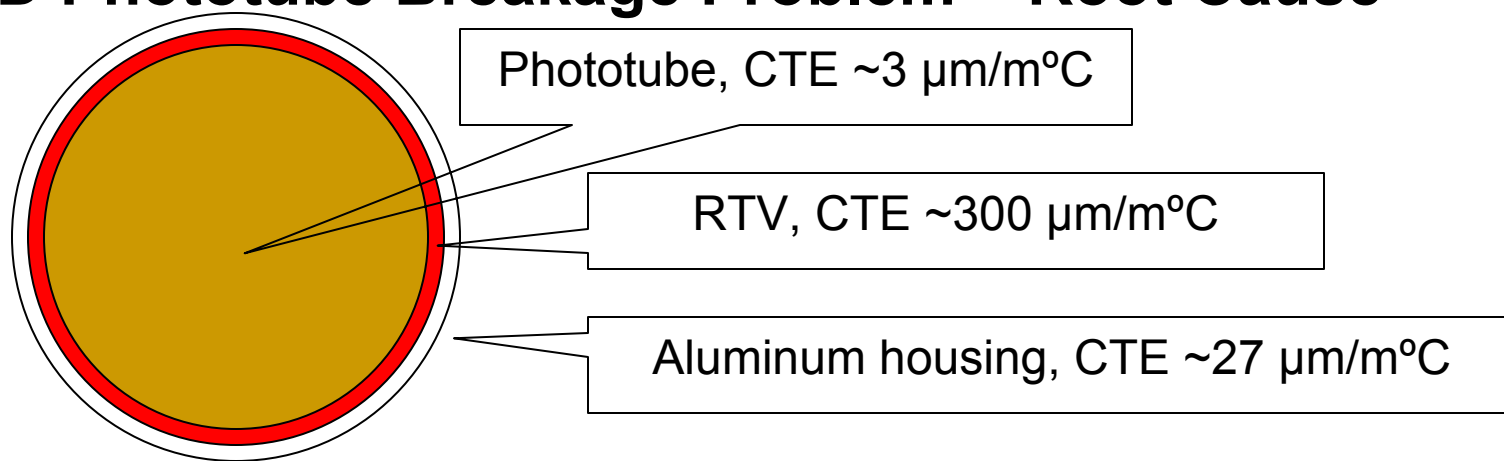
OR

De-bonding in PMTs using earlier batches. Same procedure and primer used of first 9 that passed as used for later sets. Unlikely but possible.

Further work to clarify issue (particularly why qual units did not fail) ;

- Longitudinal strain measurements – have this on some, get complete set. Should help explain if de-bonding is happening and if so why we are getting positive strain on some (in progress). Could also use analyze to predict scenarios that produce these strains with new materials properties. – early results not useful.
- Push test on PMT as goes cold and measure for shift in position
- Measure thickness of S/N 2 and 5 bond lines

ACD Phototube Breakage Problem – Root Cause



Because the RTV is used to hold the position of the tube in both transverse and longitudinal directions, it must adhere to both the tube and the housing, i.e. be primed.

Because the Coefficient of Thermal Expansion (CTE) of the RTV is much larger than that of either the tube or the housing, at cold temperatures the shrinkage of the RTV pulls on both surfaces.

If the CTE of the RTV were closer to those of the tube or the housing, we would have no problem. **BUT** – the actual CTE of the RTV is LARGER than the specifications (and from a number of early sample tests) and variable from batch to batch, and, we are learning, from cure to cure within batch.

If the RTV were compressible enough, it would stretch instead of transmitting the stress. **BUT** – the actual RTV is almost perfectly incompressible, significantly more so than the specifications. We are learning this also appears to vary from batch to batch and between cures within the same batch. Poisson's ratio is 0.49 in some samples compared to specifications of no more than 0.46.

RESULT – Combine the above facts with the fact that glass flaws in our particular PMTs make them 50 to 70% weaker than one might expect, at low temperatures the tube is pulled apart by the shrinking RTV, with cracks starting at these flaws. We believe the qual units did not fail because the earlier batches of RTV tended to have much better material properties and there may have been some de-bonding in the early batches.